SOLAR TRACKER

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Specially dedicated to
my project supervisor, family and friends who have encouraged, guided and inspired me throughout my journey of education

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ABSTACT

The report details the research and development of a single-axis Solar Tracker. Fossil fuels are a relatively short-term energy source; consequently, the uses of alternative sources such as solar energy are becoming widely spread. To make solar energy more viable, the efficiency of solar array systems must be maximized. A feasible approach to maximize the efficiency of solar array systems is sun tracking. Solar modules are devices that cleanly convert sunlight into electricity and offer a practical solution to the problem of power generation in remote areas. The solar tracker that is designed and constructed in this project offers a reliable method of aligning a solar module with the sun in order to maximize its energy output. This project consists of a light sensor that detects light intensity and needs a circuit design to measure the load. A simple voltage divider circuit is designed to achieve this outcome. A motor needs a driver circuit to determine the rotation. Each signal that enters the motor input is converted from analogue signal, sensed by the light sensor to digital signal by the ADC in the microprocessor. The values of voltage from each sensor are displayed on the LCD. The motor rotates regarding the digital signals received from the microprocessor. These digital signals are identified by certain algorithms that programmed in the microprocessor. The motor will rotate the tracker to the position where the light sensor is oriented normal to the light source. The early stage of the project is started with the circuit designs. It followed with the programming designs and ended up with prototype model designs. The project is well tested and set up for data analysis to prove the effectiveness of the Solar Tracker.

ABSTRAK

Laporan ini menjelaskan tentang kajian dan pembinaan Pengesan Solar berpaksi tunggal. Bahan api daripada fosil adalah sumber tenaga jangka pendek; akibatnya, penggunaan sumber tenaga alternative seperti tenaga solar semakin meluas. Untuk menjadikan tenaga solar satu tenaga yang berdaya maju, kecekapan sistem panel solar mesti dimaksimumkan. Satu pendekatan yang dilaksanakan untuk memaksimumkan kecekapan sistem panel solar adalah menggunakan pengesan untuk menjejak kedudukan matahari. Modul solar adalah satu peranti yang menukarkan tenaga solar kepada tenaga elektrik menawarkan penyelesaian praktikal kepada masalah penjanaan kuasa di kawasan pedalaman. Projek ini terdiri daripada sensor cahaya yang berfungsi mengesan keamatan cahaya dan perlukan litar yang sesuai untuk mengira isyarat keluarnya. Satu litar pembahagi voltan yang mudah telah dibentuk untuk mendapatkan isyarat keluar ini. Motor perlukan litar pemacu untuk berputar. Setiap isyarat yang masuk ke motor telah ditukar ke dalam bentuk digital oleh fungsi penukar analog ke digital di dalam mikropemproses. Setiap nilai voltage dari setiap sensor akan dipaparkan pada pemapar LCD. Motor berputar berdasarkan isyarat digital yang diperoleh dari mikropemproses. Motor akan memutar pengesan solar ke arah di mana sensor cahaya berada menghala tepat pada sumber cahaya. Projek ini bermula dengan rekabentuk litar pada peringkat awalnya. Diikuti dengan rekabentuk bahasa pengaturcaraan dan berakhir dengan rekabentuk model untuk prototaip. Projek ini telah diuji dengan lancar dan disediakan untuk pengumpulan data untuk membuktikan keberkesanan Pengesan Solar ini.

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AC	-	Alternate Current
BOM	-	Bill of Materials
CCS	-	Custom Computer Service
CD	-	Compact Disk
CdS	-	Cadmium Sulphide
CPU	-	Central Processing Unit
CSP	-	Concentrated Solar Power
DC	-	Direct Current
EA	-	Elliptic Axis
EP	-	Elliptic Plane
IC	-	Integrated Circuit
I/O	-	Input/Output
LDR	-	Light Dependent Resistor
PA	-	Polar Axis
PIC	-	Peripheral Interface Controller
PCB	-	Printed Circuit Board
PV	-	Photovoltaic
PWM	-	Pulse Width Modulation
RAM	-	Random Access Memory
RC	-	Radio Controlled
SLA	-	Sealed Lead Acid
SRM	-	Switched Reluctance Machine
TTL	-	Tobin Time Lapse
UV	-	Ultra Violet

CHAPTER I

INTRODUCTION

This chapter will explain further on project overview. The project background, problem statement, objective, scope and methodology are briefly explained.

1.1 Background Study

Renewable energy solutions are becoming increasingly popular and one of it is solar energy. Solar is the Latin word for sun, a powerful source of energy that can be used to heat, cool, and light our homes and businesses. That is because more energy from the sun falls on the earth in one hour than is used by everyone in the world in one year.

Extracting useable electricity from the sun was made possible by the discovery of the photoelectric mechanism and subsequent development of the solar cell, a semi-conductive material that converts visible light into a direct current. By using solar arrays, a series of solar cells electrically connected, a DC voltage is generated which can be physically used on a load. Solar arrays or panels are being used increasingly as efficiencies reach higher levels, and are especially popular in remote areas where placement of electricity lines is not economically viable.

This alternative power source is continuously achieving greater popularity especially since the realisation of fossil fuel shortcomings. Renewable energy in the form of electricity has been in use to some degree as long as 75 or 100 years ago. Sources such as solar, wind, hydro and geo-thermal have all been utilised with varying levels of success. The most widely used are hydro and wind power, with solar power being moderately used worldwide. This can be attributed to the relatively high cost of solar cells and their low conversion efficiency.

1.1.1 Solar Energy

Solar energy, radiant light and heat from the sun, has been harnessed by humans since ancient times using a range of ever-evolving technologies. Solar energy technologies include solar heating, solar photovoltaic, solar thermal electricity and solar architecture, which can make considerable contributions to solve some of the most urgent problems the world now faces.

Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Active solar techniques include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favourable thermal mass or light dispersing properties, and designing spaces that naturally circulate air.

1.1.2 Solar Power

Solar power is the conversion of sunlight into electricity, either directly using photovoltaic (PV), or indirectly using concentrated solar power (CSP). Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Photovoltaic converts light into electric current using the photoelectric effect.

1.1.3 Solar Tracker

A solar tracker is a device that orients various payloads toward the sun. Payloads can be photovoltaic panels, reflectors, lenses or other optical devices. In flat-panel photovoltaic (PV) applications, trackers are used to minimize the angle of incidence between the incoming light and a photovoltaic panel. This increases the amount of energy produced from a fixed amount of installed power generating capacity.

Light gathering is dependent on the angle of incidence of the light source providing power to the solar cell's surface, and the closer to perpendicular, the greater the power. If a flat solar panel is mounted on level ground, it is obvious that over the course of the day, the sunlight will have an angle of incidence close to 90° in the morning and the evening. At such an angle, the light gathering ability of the cell is essentially zero, resulting in no output. As the day progresses to midday, the angle of incidence approaches 0°, causing steady increase in power until at the point where the light incident on the panel is completely perpendicular, and maximum power is achieved. As the day continues toward dusk, the reverse happens, and the increasing angle causes the power to decrease toward minimum again.

From this background, the need to maintain the maximum power output from the panel by maintaining an angle of incidence as close to 0° as possible by tilting the solar panel to continuously face the sun, this can be achieved. This process of sensing and following the position of the sun is known as solar tracking. It was resolved that real-time tracking would be necessary to follow the sun effectively, so that no external data would be required in operation.

1.2 Objective

Maximizing power output from a solar system is desirable to increase efficiency. In order to harvest the optimum power output from solar panel, one needs to keep the panels aligned with the sun. For this, tracking the sun ray direction is required. This is a far more cost effective solution than purchasing additional solar panels. It has been estimated that the yield from solar panels can be increased by 30% to 60% by utilizing a tracking system instead of a static array.

Essentially, the main objectives for this project are to develop a single axis solar tracking system prototype using electronic components and to make comparison on voltage, current and power produced by a solar panel placed towards static direction and a solar panel placed on the solar tracker.

The objectives mentioned will be achieved by conducting studies on the components needed to detect light intensity, motor control to move the tracker, microcontroller to control the tracker position automatically so that the whole system can operate properly.

1.3 Problem Statement

As solar energy is known as one of the renewable energy solution, there is a main problem that holding up the efficiency of the solar tracking system. The problem that occurs now is most of the solar panels are commonly placed in static orientation on building or residential rooftops. If the solar panel is oriented to east and the sun is located at west, the optimum power output cannot be generated. If the sun location is not normal to the solar panel orientation, the power that can be generated is less compared to when the sun is located exactly normal to the solar panel orientation.

The possible maximum power output only can be generated when the solar panel is oriented to the location of the sun. The solar tracking device will detect the maximum light intensity to achieve the objectives.

1.4 Scope

The proposed project is to design a single-axis solar tracking system prototype consists of light sensor, microcontroller, motor and prototype model. As it is a single-axis tracking system, the tracking angles are within 0° to 180°.

As the light sensor detects the light intensity, the parameters of light intensity need to be measure according to brightness of light at different time and place. A threshold signal from the light sensor can be determined based on these conditions of light brightness. Light dependent resistor (LDR) and photodiode are amongst type of light sensor.

Microcontroller is used as the whole project operation controller. Specifications of a microcontroller need to be identified to ensure it is compatible to the system. Peripheral Interface Controller (PIC) is amongst the suitable type of microcontroller for this project.

The specifications of a motor are important to rotate the tracker to the optimum possible angle which normal to the light source. Different type of motor indicates different way of rotation. DC motor, stepper motor and servo motor are amongst the type of motor that capable to rotate the tracker. The different operation of each types of motor needs to be analyzed to come up with the best selection which suites this project.

Appropriate software is used to design the programming and circuit simulation. Proteus Professional 7 is used for the circuit simulation and Printed Circuit Board (PCB) fabrication and MPLAB IDE v8.36 for the programming codes. These software are capable on achieving the expected results.

1.5 Methodology

During the implementation period, project planning is the most vital aspect. A proper plan ought to be emphasized to make sure the undertaking will be crafted prosperously and additionally to circumvent difficulties as acting the project. It is extremely vital to have this systematic planning and implementation in order to complete the project hardware and software part and come out with a functional prototype. Figure 1.1 shows the block diagram of the project.

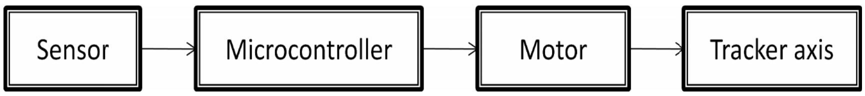

Figure 1.1: Block Diagram of the Project

This project is focusing on building the solar tracking system prototype that orients the tracker normal to light source at optimum possible angle. The project is focusing on building the light tracking device to align the tracker direction normal to the light source and the power harvesting module is not included.

The methods include the listing of the electronic components for sensing unit and motor control, simulation of circuitries to obtain desired outcomes using suitable software, using a microcontroller that control the system operation, designing a programming for the microcontroller using appropriate and simple machine language, designing the prototype frame and assembling the circuit and the frame to come up with a functional prototype model.

1.6 Report Structure

This report is presented in five chapters. Each chapter consists of brief explanation of the project background and implementation.

In chapter I, the brief overview of the project is discussed. The project background, problem statement, objective, scope and methodology are reviewed briefly.

Chapter II consists of variety of findings from journals and other source of information. All findings that related and relevant for this project are concluded and explained in this chapter.

In chapter III, the methods used in this project implementation are explained. Planning is the most vital aspect on completing this project. This chapter consists of the steps needed to accomplish the objective of this project. Every phase is discussed thoroughly from the process of designing the circuitries to the assembling of the prototype model.

Chapter IV consists of the results obtained from the simulation and functional prototype demonstration. The results are discussed and arranged in suitable methods.

The last chapter consists of the conclusion made from the whole process regarding this project. This chapter also consists of recommendation of improvement that can be achieved from this project for future appliances.

CHAPTER II

LITERATURE REVIEW

This chapter consists of findings gathered from the literature reviews of the related topics. The journals that have been collected and studied are based on the Solar Tracker project. These journals contain the fundamentals of solar energy, solar tracking system and information about the electronic components, hardware implementation and data acquisitions from the simulations made by previous researchers. These connected works have been studied prudently in order to enhance the quality and reliability of this project.

By analyzing the previous undertakings by supplementary researchers, there is a potential to understand that a little features are lacking in their projects. Moreover, there are several functional methods from the previous projects that can be implemented in this project. Therefore, the working principle and methods of the previous projects need to be analyzed and studied to come out with the best conclusion for the project. By studying the previous works, a proper design on how this project can be led and the features that have to be added in order to make this project reliable and marketable are enlightened. In addition, findings from the internet and books are also used for reference.

2.1 Solar Power

Solar power received on the surface of any object on the earth could be considered as the power absorbed in the entire volume of that object and hence measured in Watts per unit volume. Variations in solar radiation intensity based on the angles of the Sun during the day and the year is briefly reviewed. It is shown how the wide ranges of these variations can affect efficiency of a solar power generating system and its energy delivery. Module of Irradiance and Collectivity Factors are introduced as parameters to estimate power/energy entering a volume and the efficiency of the system. A solar power tracking concept is analyzed and shown how it would significantly increase the efficiency of the system. Feasibility of tracker in solar power generation is studied based on tracking factor [1].

The sun is the main source of energy for the earth's surface. It has served the life on earth with its endless radiation source for millions of years. At this era of human technology and environmental crisis, the solar energy is still considered a major alternative for a safe and clean environment. Solar radiation is a major source of energy in the nature that circulates the ocean, runs water on the ground, blows winds in the air and continuously changes the face of earth. In the world of life, the sun energy is the first resource of all motions in the living cells. This energy in the first stage is collected by the plants and mostly absorbed through the leaves of trees, the green thin sheets of cellulose and water exposed to the solar beams. The layers of chlorophyll in the leaf convert this radiation to chemical energy required for all the food chain in life on the earth. Even the fossil energy we use today as coal or petroleum is the far past remnant of the solar energy radiated over the millenniums. A progressive technology today is to collect the radiation from the sun is Photo Voltaic (PV) panels. This element could be compared with a leaf of a tree. A mass of silicon with an expanded surface can similarly absorb the solar radiation in layers of its crystallized molecules [2].

However, the leaves are not usually arranged on a flat surface but spread in the whole volume of a plant. That is why the trees tend to grow vertically to get most of the solar rays in a volume. To install the PV panels on a tall structure is more costly than laying them down on the ground. However, depending on price of land